Statement by

Dr. Harry H. Hess
Chairman, Space Science Board
National Academy of Sciences
before the
Committee on Aeronautical and Space Sciences
U. S. Senate

June 11, 1963

National Goals in Space

If we are willing to put the required effort into an immense engineering and development program, no one doubts that we can land men on the Moon a few years from now. This is the challenge which President Kennedy has accepted for the Nation. It is a great adventure which fires the hearts of men. Shall we settle comfortably before our television screens or shall we sweat, struggle and deprive ourselves of some comforts to accomplish this mission? The position of our particular society in the world today is not the result of shrinking from challenge, rather we, as a nation, have historically accepted work, sacrifice and heartache to achieve our current status.

Landing a man on the Moon is a simple and specific goal -- an inspiring goal -- easily understood by the man in the street. Although it is primarily an engineering, technological, and biomedical project, it is a necessary developmental project for the basic scientific effort to follow. However, many scientists urge that we abandon manned landing and rely on measurements by electronic instruments. The first fallacy in this argument is that funds are not transferable in this manner. Remove the goal which appeals to the public and the appropriations go with it. But more important is the fallacious notion that instruments can ultimately replace the man. Instruments are quite satisfactory for measuring many of the gross properties of the Moon and for observing the expected. For these observations no man on the spot is required. By the time of the third manned landing one would hope to include an able scientist in the crew. This man can look around and at a glance pick the significant item or anomaly from among the tens of thousands of items which might be examined. When this point is reached the man becomes vastly more efficient than the instrument because he can discriminate, find, and interpret the unexpected. In missions far beyond the Moon, the need for manned operations increases so that manned lunar landing becomes the training and development ground for later solar system exploration.

Philosophically, Mahan's strategic concepts of sea power can be extended to a third dimension: He who controls the three-dimensional environment might well become the dominant power on the Earth. However, there is no obvious military use for the dimension of space alone at the present time except the minor defensive one of surveillance of that part of the Earth's surface denied to us by present political situations. Nevertheless, we cannot, without grave risk, afford to let others develop the capability of exploiting space unless we develop a parallel capability against the unforeseen needs of the future. Obviously we cannot wait until a crisis arises because we probably cannot meet this type of emergency by a crash program. The insurance provided by planned expenditures on the space program are warranted for this reason alone.

Great technological advances commonly have been a by-product of wars since the industrial revolution. The space program supplies an equivalent motivation without the disastrous effects of combat. Thus, quite logically, one of the factors mentioned in connection with the space program is "spin-off." These by-products fall into two categories: First, those of an obvious applications nature: communications, meteorology, navigation -- these are easy to discuss and understand. The second category is much more difficult to appreciate and appraise: the improvement in fuels; the increased activity in metallurgy; the development, by necessity, of more precise standards of measurements and techniques; increased emphasis on quality-control -- which will result in improvement in manufacturing generally; and in fact the whole structure of basic research is being stimulated in many ways.

Just over the horizon in the first category -- and of immediate benefit -- is an obvious major breakthrough in communications which should have profound effects on our economy as well as on that of other nations advanced far enough to take advantage of it. The potential of the communications satellite is much clearer than the effect of the automobile as seen in 1910 or the airplane in 1920 or, more appropriately, the telephone and then the radio as seen early in this century. Other applications of the space program are of like magnitude: The possible effect of improved meteorological services on long-range forecasting and hence on agriculture could be great. The study of physiological effects on man of the space environment will almost surely lead to advances in medicine.

Turning now to research in space, we find that the availability of vehicles capable of penetrating far beyond the Earth's atmosphere makes possible the direct study of many important scientific problems. Until very recently the scientist has been tied to Earth-bound observations necessarily screened by the Earth's atmosphere. Let us look at some of the areas of research that have been opened by balloons, sounding rockets, satellites and space probes.

The present-day burst of our space program, as you know, had its beginnings as a component of the scientific program of the IGY. The IGY program was developed around available, or easily modified, rocket vehicles, relatively modest in size, and thus had to rely on instruments to make measurements and make reports. The scientists who were involved in this new field were those interested in understanding first the Earth itself and its surrounding atmosphere; second, the interplanetary medium; third, the Moon and the planets, and fourth, the Sun and other stars. They were interested in this newly available laboratory in space, for now direct examination of previously unreachable things seemed at hand. Thus, it is easy to see how science, and scientists, emerged as the reason for and the supporters of the Space Program.

Let me, for a moment, elaborate on each of these four topics working outward from our own planet:

Earth and Near Space

We can study the solid Earth to advantage by means of spacecraft in a way that Earth-bound observations could not hope to do: the Earth's size and shape, its hidden structure, the gravitational field, and the like. The Tiros series of satellites have already made contributions to the meteorologist's understanding of the weather; sounding rockets of the meteorological rocket network are also providing valuable synoptic data. Further out, the ionospheric layers of our atmosphere, the magnetic field, the influences of the Sun and its activity present a complex array of questions to the physicist, chemist, geophysicist and astronomer.

Interplanetary Medium

The upper atmosphere blends into the interplanetary medium with no sharp line of demarcation. Interest in the interplanetary medium has several purposes, quite aside from the quest for knowledge. Knowledge of events in this expanse of space will shed light on events in near space and the upper atmosphere. It affords a basis for coping with difficulties in exploring, by instruments and by man, the interplanetary medium and its content in greater detail and over extended range in the next decade and beyond. It affords a basis for surer extrapolations from our increased knowledge of the solar system to other, similar systems elsewhere in our own and other galaxies. These general objectives can be attained with spacecraft of modest payloads: (a) satellites in large or very elongated orbits and (b) space probes launched in predetermined sequences and patterns adequately to sample the breadth of the interplanetary medium.

<u>The Moon and the Planets</u>

Soon we will land automated instruments on the Moon and further in the future some of the planets. In this decade man himself will reach and return from the Moon. Why is science concerned with these bodies? The planets of the solar system are part of the whole -- in their origins, in their present states, and in their futures. For the first time in history, man has it within his power to investigate these bodies, and what he learns will be a significant addition to man's total knowledge. The possibility that some form of living matter exists on another planet is the most exciting prospect: the origin of life under radically different conditions of environment and ecology is a subject of unprecedented significance to science. As to this, Mars is the most exciting by virtue of its astronomically known character, which suggests the possibility of some form of living matter.

The Moon is a most appropriate object of study because there is a likely parallel with the Earth in origin and history. Its surface layers have not weathered as have those of the Earth, and therein may lie clues both to its and to the Earth's early history and development.

The more distant planets pose problems for exploration, the solutions of which lie far in the future. Mars and Venus, however, are accessible by spacecraft. The compositions, depth, densities and temperature distribution of their atmospheres can be studied by space probes and planetary satellites. An artificial satellite orbiting about Venus would permit the conduct of such important experiments as a study of the composition of the clouds of Venus, determination of its mass and mass distribution, measurement of the spectrum of its dark side, photography at various wavelengths, and such physical measurements as those associated with magnetic fields and charged particles. Similar experiments should be conducted aboard a Martian satellite. Both planets, but especially Mars, should be investigated for the presence of living organisms. TV observations from a planetary satellite may yield some information as to this, but more promising and detailed examinations are possible when automatic instruments can be soft-landed. Hard, soft, and ultimately manned landings: each approach will extend the range of possibilities in the study of these planets, just as in the case of the Moon.

In brief, the observations of the highest significance are those that shed light on the nature, origin, and evolution of the planetary system and of life within it. Mariner II has already given us valuable data on Venus; the Moon and Mars are now on the verge of meaningful accessibility, and eventually it should be possible to turn also to other planets.

The Sun and the Stars

Our interest in the Sun is obvious. Life and activity on Earth are dependent upon solar energy and have always been. Light and heat are but a small portion of the full range of radiation and particles emitted by the Sun, many of which reach at least the higher zones of the Earth's atmosphere. Interest in the Sun is aroused because the Sun is our nearest star, an average star whose study is relevant to our notions of other stars.

From Galileo until the closing years of the nineteenth century solar astronomy was largely observational, statistical, and descriptive. Spectroscopy and atomic theory have led to major advances during the last 80 years, providing quantitative knowledge of many aspects of the Sun, but much remains to be done. The whole range of solar short-wave radiation -- ultraviolet, X rays, and gamma rays -- calls for measurements from beyond the interfering layers of the Earth's atmospheres: line spectra to the shortest possible wavelength and greatest resolution, measurements of radiation intensity for the entire run of spectral bands from x-ray to radio frequencies, profiles of lines such as Lyman-alpha and their variation from center to limb, x-ray intensity measurements from flares and other sources. The extreme short-wave radiations originate in high-temperature solar processes; moreover, in contrast to the better known aspects of the Sun -- light and heat radiation, which are thought to be quite steady-- the high-frequency radiations are extremely variable on a short time scale.

I have touched on these arbitrary subdivisions only to relate science to the space program and its evolution. Now I think it is quite understandable that we as scientists prefer to be present when we run an experiment in our laboratories. In some rare cases, it's true, we depend on remote control and indirect measurement, but the polar researchers insist on spending the winter in the Antarctic, the oceanographer risks his life in the depths of the seas, and the medical scientist exposes himself to the deadly virus -- instruments just are not satisfactory substitutes. So it is too with research in space -- when it is technologically feasible for man to go it is inevitable that he must go. The Space Science Board, under the distinguished leadership of Lloyd Berkner, recognized this fact -- and I might say not without reluctance -- more than two years ago.

The Space Science Board was established by the President of the National Academy of Sciences (then Detlev W. Bronk) in June 1958, predating the National Aeronautics and Space Administration by several critical months. Now, while I'm not here to review the Board's history, I do wish to point out some relevant Board studies. First

NASA's initial scientific program was based on experiments collected by the Board from the scientific community, and, after review, transmitted to the Government in December 1958. Second, the Board fostered in 1961 the preparation of a series of reports by distinguished scientists reviewing current knowledge of Gravity, The Earth, The Moon and The Planets, Fields and Particles in Space, The Stars, The Life Sciences, and pointing out the opportunities for research in each field. These chapters were subsequently expanded and published in book form (Science in Space, L. V. Berkner and Hugh Odishaw eds., McGraw-Hill Book Co., New York, 1961). Third -- I alluded to this earlier -- in February 1961 the Board issued a policy statement defining the role of man in the space program. On repeated review, most recently last month at the twelfth meeting of the full Board, I find we on the Board still hold to this position:

> "From a scientific standpoint, there seems little room for dissent that man's participation in the exploration of the Moon and planets will be essential, if and when it becomes technologically feasible to include him. Man can contribute critical elements of scientific judgment and discrimination in conducting the scientific exploration of these bodies which can never be fully supplied by his instruments, however complex and sophisticated they may become. Thus, carefully planned and executed manned scientific expeditions will inevitably be the more fruitful.
>
> "There is also another aspect of planning this country's program for scientific exploration of the Moon and planets which is not widely appreciated. In the Board's view, the scale of effort and the spacecraft size and complexity required for manned scientific exploration of these bodies is unlikely to be greatly different from that required to carry out the program by instruments alone. In broad terms, the primary scientific goals of this program are immense: a better understanding of the origins of the solar system and the universe, the investigation of the existence of life on other planets and, potentially, an understanding of the origin of life itself. In terms of conducting this program a great variety of very intricate instruments (including large amounts of auxiliary equipment, such as high-powered transmitters, long-lived power supplies, electronics for remote control of instruments and, at least, partial data processing) will be required. It seems obvious that the ultimate investigations will involve spacecraft, whether manned or unmanned, ranging to the order of hundreds of tons so that the scale of the vehicle program in either case will differ little in its magnitude.

"While the Board has here stressed the importance of this policy as a <u>scientific</u> goal, it is not unaware of the great importance of other factors associated with a U. S. man in space program. One of these factors is, of course, the sense of national leadership emergent from bold and imaginative U.S. space activity. Second, the members of the Board as individuals regard man's exploration of the Moon and planets as potentially the greatest inspirational venture of this century and one in which the entire world can share; inherent here are great and fundamental philosophical and spiritual values which find a response in man's questing spirit and his intellectual self-realization. Elaboration of these factors is not the purpose of this document. Nevertheless, the members of the Board fully recognize their parallel importance with the scientific goals and believe that they should not be neglected in seeking public appreciation and acceptance of the program."

The fourth study, most recent and most extensive, was conducted under Board auspices at the State University of Iowa during an eight-week period last summer. Conducted with the cooperation of the National Aeronautics and Space Administration, the Department of Defense, the National Science Foundation, the Atomic Energy Commission, and with the active participation of more than one hundred scientists, the study was able to assess in detail each subject matter area of the space program. In fact, I believe the report of this study, <u>A Review of Space Research</u> (1963), is so important to an understanding of the space program that I am including it as an annex to these remarks. In particular, I would refer you to the chapter on Biology, which I believe puts the manned flight program in perspective, and to the excellent chapter on Man as a Scientist.

I have detailed these Board studies because they have been conducted by and represent the considered opinion of a large segment of the scientific community. Furthermore, they show an evolution of thought on man's role in this space business. The first study dealt only with instruments, while the other three considered man and science together. These programs go together. Let's not try to separate one from the other. I believe, as our studies indicate, that man is required for our investigations just as soon as the technology can put him there.